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# Understory Production Not Predictable From Aspen Basal Area or Density

Kieth E. Severson and Jeremiah J. Kranz[1]

Analysis of effects of aspen basal area and density on production of understory vegetation revealed no useful predictive relationships using the model log Y = a + bX. However, as the proportion of ponderosa pine basal area increased in aspen-pine stands, understory production declined in a predictable manner. Root biomass, total biomass, and/or growth rate of aspen may be more closely related to understory production than measures of aspen overstory.

**Keywords:** *Populus tremuloides*, understory-overstory relationships, wildlife habitat.

Stands of quaking aspen (*Populus tremuloides*) have been recognized as an important habitat component for wildlife as well as valuable forage for livestock in the Black Hills and adjacent Bear Lodge Mountains. Increased emphasis is being placed on intensive management of aspen stands, particularly for ruffed grouse (*Bonasa umbellus*) and white-tailed deer (*Odocoileus virginianus*).

However, resource managers need more knowledge of the aspen complex to effectively manage for maximum ecosystem output. We tested Black Hills aspen data to determine if understory production could be predicted from selected attributes of the aspen overstory. This Note describes our efforts.

## Previous Work

Most studies relating overstory crown cover or basal area to understory have revealed that understory forage production decreases as crown cover or basal area increases. Examples include Pase (1958) in Black Hills ponderosa pine, Ehrenreich and Crosby (1960) in hardwood stands in Missouri, Halls and Schuster (1965) in pine-hardwood forests in Texas, and McConnell and Smith (1970) in ponderosa pine in Washington. These researchers developed mathematical models that permitted resource managers to predict forage yields when overstory parameters were known. Jameson (1967) stated that inverse relationships found in such studies were reasonable because of competition for water, light, and nutrients.

When Harper (1973) worked in aspen forests of central Utah, he discovered that tree basal area was not correlated with annual production of the understory when aspen was the only tree present. If conifers were mixed with aspen, however, understory production declined rapidly as tree basal area increased. He attributed this decline to the influence of conifers.

Ellison and Houston (1958), while not attempting to relate overstory-understory attributes, did compare production of herbaceous vegetation under aspen and in adjacent openings. They also studied the differences between trenched (to remove competition from aspen roots) and untrenched plots under aspen. They found that openings adjacent to aspen stands produced more than untrenched plots under aspen, but that growth on trenched plots exceeded or equaled that in openings.

[1]*Severson is a Range Scientist, located at the Station's Research Work Unit at Rapid City; Station's central headquarters is maintained at Fort Collins, in cooperation with Colorado State University. Kranz is a Research Biologist with the South Dakota Department of Game, Fish and Parks, Rapid City.*

## What We Did

We randomly placed twelve 100- by 100-foot macroplots in representative aspen stands. These plots were fenced to include a 25-foot buffer strip on each side. Diameter at breast height (d.b.h.) was measured on every tree within each macroplot. Stand attributes calculated were basal area ($ft^2$/acre) and density (stems/acre).

We estimated understory production in late August 1972 and 1973, using a double sampling procedure and ratio estimators as described by Blair (1958). Sixty 1- by 2-foot plots were randomly placed within each macroplot. Weights on these small plots were estimated and corrected to an ovendry basis.

Data were tested using the regression analysis model log Y = a + bX; overstory attributes were considered the independent variables (X) and production of understory components the dependent variables (Y). All statistical tests were made at the P = 0.05 level.

## What We Found

Overstory characteristics and understory production, by forage class for each of 2 years, are listed by stand in table 1. D.b.h. was measured at the end of the 1972 growing season, and it was assumed no major increments were added in 1973. Therefore, the same overstory data were used over both years.

Growing season precipitation (April through August) between the 2 years was variable over the Hills region, but was generally lower in 1973. April-August precipitation was 16, 27, and 37 percent less in 1973 than in 1972 at Sundance, Wyoming, and Deadwood and Spearfish, South Dakota, respectively, but was 11 percent higher at Deerfield, South Dakota. Total forage production was significantly lower in 1973, although decreases in individual classes—shrubs, forbs, and graminoids—were not significant.

No significant correlation coefficients (r) were observed when we used basal area as the independent variable. Additionally, of the eight tests made with basal area (production of shrubs, forbs, graminoids, and total for each of 2 years) four demonstrated a positive relationship and four were negative. Coefficients of determination ($r^2$) indicated that basal area in the model accounted for less than 30 percent of the variation.

Density of aspen stems had no significant effects in five tests. A positive correlation between aspen density and shrub production (r = 0.68, 1972; and 0.62, 1973) was significant. However, the resulting equations accounted for less than 50 percent of the variation in both cases.

Forb production demonstrated a significant negative correlation (r = -0.74) with aspen density, but only for data collected in 1973, the drier year.

Conifer reproduction in the 12 study areas was insignificant, and the influence of invading ponderosa pine (*Pinus ponderosa*) could not be evaluated. However, using data presented by Kranz and Linder (1973) for Black Hills aspen-ponderosa pine communities, we found that aspen basal area accounted for only 41 percent of the variation in understory production (positive correlation, r = 0.64). Pine and total basal area, in contrast, were useful predictors of total understory production in the equations log Y = 2.835 - 0.0027X, when X = pine basal area; and log Y = 3.235 - 0.0050X, when X = total basal area (pine and aspen). Correlation coefficients for the two relationships were -0.87 and -0.95, respectively.

## Our Interpretation

We found no useful relationships between understory production and basal area or density of aspen. No prediction equations could be developed using the model log Y = a + bX. Although other models are available, examination of the data in table 1 indicates they would probably yield similar results. As coniferous species invade, however, understory production declines in a predictable manner related to both increasing basal area of pine and total basal area. This is consistent with information reported by Harper (1973) for aspen in the mountains of central Utah.

Data collected for this study were insufficient to explain why understory production was not related to these aspen characteristics. This phenomenon is interesting, however, particularly when similar studies in both hardwood and conifer types have indicated a predictable relationship. Aspen has two somewhat unique characteristics that could help explain why such relationships are not apparent. This species reproduces primarily by sprouting from lateral root systems. Secondly, the aspen community is generally regarded as a seral stage preceding a climax coniferous stand. Rates of succession, however, vary considerably. Certain aspen stands are so stable that some investigators regard them as climax (Reed 1971, Wirsing 1973). If the seral stage is measured in terms of conifer invasion, the problem of predicting understory production becomes less acute. If conifer invasion is negligible, as in the climax *Populus tremuloides-Symphoricarpos orephilus* association described by Reed (1971) or in younger seral stands that have not been invaded by conifers, other parameters must be considered as independent variables.

Studies by Ellison and Houston (1958) of production on trenched and untrenched plots in aspen stands have indicated that aspen root systems do have a significant influence on understory growth. If an existing aspen stand is destroyed (by fire, cutting, or disease) a new stand can regenerate from the existing root system. Such stands, after suffering one or

Table 1.--Per-acre comparison of understory production with basal area and density of aspen on 12 quaking aspen areas in the Black Hills and Bear Lodge Mountains, 1972 and 1973

| Aspen stand | Aspen overstory, 1972-73 | | Understory production, 1972 | | | | Understory production, 1973 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Basal area | Density | Shrubs | Forbs | Graminoids | Total | Shrubs | Forbs | Graminoids | Total |
| | *Ft²/acre* | *Stems/acre* | | | | *Lb/acre* | | | | |
| 1 | 120 | 1429 | 266 | 353 | 390 | 1009 | 137 | 187 | 342 | 666 |
| 2 | 116 | 553 | 159 | 335 | 208 | 702 | 85 | 291 | 171 | 547 |
| 3 | 106 | 1115 | 271 | 149 | 59 | 479 | 359 | 252 | 121 | 732 |
| 4 | 104 | 815 | 152 | 246 | 110 | 508 | 116 | 236 | 170 | 522 |
| 5 | 96 | 1403 | 67 | 485 | 532 | 1084 | 73 | 164 | 475 | 712 |
| 6 | 94 | 3925 | 466 | 160 | 228 | 854 | 510 | 109 | 193 | 812 |
| 7 | 84 | 1477 | 330 | 86 | 107 | 523 | 522 | 135 | 72 | 729 |
| 8 | 83 | 1581 | 104 | 358 | 724 | 1186 | 84 | 283 | 307 | 674 |
| 9 | 82 | 2962 | 486 | 262 | 98 | 846 | 420 | 129 | 113 | 662 |
| 10 | 75 | 1673 | 147 | 490 | 557 | 1194 | 76 | 382 | 421 | 870 |
| 11 | 50 | 2365 | 374 | 171 | 184 | 729 | 228 | 102 | 149 | 479 |
| 12 | 42 | 3197 | 507 | 125 | 103 | 735 | 347 | 82 | 74 | 503 |

several perturbations, would have root systems considerably different from stands that had not been disturbed. It would be hypothetically possible to find stands of equal basal area or density originating from completely different root systems. A more complex, extensive root system may result in a more actively growing stand that removes more moisture and nutrients from the soil, thus competing with understory plants to a greater degree.

The several studies we reviewed made no mention of grouping sampled areas according to similar site characteristics before analysis. Site attributes were described only in general terms for the entire study area. In these studies, high correlation between overstory parameters and understory production apparently obviated the need for such grouping.

This led us to make the initial assumption that, although site differences influence total productivity, they do not necessarily influence the relationships between overstory and understory. Thus, we made no effort to select similar aspen sites for this analysis, and intentionally included different kinds of aspen stands. Therefore we must admit that we might have found higher correlations had we grouped aspen stands with similar site characteristics.

Root biomass, total biomass, and/or growth rate of aspen as affected by number of perturbations, seral stage, age of stand, and site characteristics may be more closely related to understory production than density and basal area of the existing aspen overstory. Such parameters would be difficult to measure, however, and their usefulness for management is therefore limited.

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